Project Report: GEOPULSE (Gene Expression of Observations for Planetary Life Study)

Lead Team:	***Pennsylvania State University***
Project Title:	***GEOPULSE (Gene Expression of Observations for Planetary Life Study)***
Project Investigator:	***Christopher House***

Project Progress

The goal of this project was to form links between microbial geobiology and genomics.

Particularly exciting results came from the investigation of anaerobic methane oxidation. We developed a method to directly couple isotopic and phylogenetic analysis of cells. As reported in two papers, we were able to link the uncultured archaeal groups ANME−1 and ANME−2 to the process of anaerobic methane oxidation.

An exciting area of research has been the continuing use of complete genome sequences to explore microbial phylogenetics. This year, we explored the effects of lateral gene transfer to the results and explored the potential to use partial genome data for tree building. We also investigated the relations of animal phyla producing a tree supporting the Coelomata over the Ecdysozoa. Our newest results are related to the phylogenetic relations within the Archaea. Our latest tree includes a number of methanogens − providing a view that the group (along with *Archaeoglobus*) forms a clade in contrast to the ordering suggested by rRNA analysis. This is a very important result as it provides a node on the tree that can be linked with the geochemical process of methanogenesis.

We have also been looking at the geomicrobiological signatures of life. We have conducted a number of experiments investigating the degree of anaerobic methane oxidation possible by a number of known methanogenic and micro−methanogenic Archaea, including members of the archaeal sulfate−reducing genera *Archaeoglobus*. Furthermore, a paper on carbon isotopic fractionation has been submitted to *Organic Geochemistry*, while further research into carbon isotopic fractionation by methanogens proceeds this summer. We are also working on a new FISH−SIMS method for measuring trace metals in cells from natural environments, a project that may provide a method for inferring biochemical attributes of uncultured cells.

Finally, *Pyrobaculum aerophilum* has been shown to extract Tunsten from basalt at 100°C.

Highlights

- Both ANME−1 and ANME−2 are involved with the anaerobic oxidation of methane. This result provides important new information regarding the impact of these uncultured organisms on the Earth and the history of the Earth.

- *Pyrobaculum aerophilum* has been shown to extract Tunsten from basalt at 100°C. This is a very significant result, suggesting a novel microbial−rock interaction in hydrothermal vents, and a potential geochemical signature of life.

- Whole−genome content tree analysis supports Coelomata over the Ecdysozoa for the relationships of animal phyla. This result is important because it suggests a particular way in which animals evolved.

Roadmap Objectives

- ***Objective No. 4:*** Genomic Clues to Evolution
- ***Objective No. 6:*** Microbial Ecology
- ***Objective No. 7:*** Extremes of Life

Mission Involvement

Mission Class*	***Mission Name (for class 1 or 2) OR Concept (for class 3)***	***Type of Involvement*** **
3	Life detection	The work provides the basis for future novel methods of life detection.

* Mission Class: Select 1 of 3 Mission Class types below to classify your project:
1. Now flying OR Funded & in development (e.g., Mars Odyssey, MER 2003, Kepler)
2. Named mission under study / in development, but not yet funded (e.g., TPF, Mars Lander 2009)
3. Long−lead future mission / societal issues (e.g., far−future Mars or Europa, biomarkers, life definition)

** Type of Involvement = Role / Relationship with Mission
Specify one (or more) of the following: PI, Co−I, Science Team member, planning support, data analysis, background research, instrument/payload development, research or analysis techniques, other (specify).

Carbon isotopic compositions of total biomass and of biomolecules are important ways to study fossil or modern microorganisms from the environment without growing them in the laboratory. These techniques being

developed will be important tools for the search for past or present microbial life on the Earth or Mars.

Cross Team Collaborations

This work represents collaborations between several NAI teams principally, Penn State and UCLA.

Also, collaboration efforts involved NAI members from the Rhode Island team and the Ames team.